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## ***Helorus arturi* sp. nov. (Hymenoptera, Proctotrupoidea, Heloridae) from Baltic amber**

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Heraty *et al.* (2011) and Sharkey *et al.* (2012) defined their Proctotrupoidea *s. str.* as a monophyletic group, a clade, using analytical methods and including all relevant extant taxa. These analyses strongly supported the monophyly of their new concept of the superfamily Proctotrupoidea. It included seven families: Austroniidae, Heloridae, Peleciniidae, Peradeniidae, Proctotrupidae, Roproniidae and Vanhorniidae. Diapriidae and Monomachidae, formerly considered to be proctotrupoids, were placed (with other taxa) in the sister-group to Proctotrupoidea *sensu stricto*.

Depending on the data sets and analytical methods used, there was some variation as to the hypotheses of the relationships within the Proctotrupoidea (Sharkey *et al.*, 2012). Their total evidence symmetric-sampling tree with relative support values (see Goloboff *et al.*, 2003) is here accepted as the best hypothesis for Proctotrupoidea phylogeny. This tree was fully resolved with respect to Proctotrupoidea: (Peradeniidae (Roproniidae (Peleciniidae (Austroniidae (Vanhorniidae (Heloridae, Proctotrupidae)))))). These analyses did not include Renyxiidae Kozlov, a family placed in Roproniidae by Ronquist *et al.* (1999) – for the correct name for the junior homonym *Renyxia* Kozlov, see Lelej & Kozlov (1999).

Extant Proctotrupoidea in this new sense is comprised of one moderate-sized family, Proctotrupidae, and six very small families. Three of them have an extensive fossil history (Ren *et al.*, 2019). Heloridae includes one extant genus with some ten species, one extinct species from Oligocene and about ten Jurassic or Cretaceous genera with 20 species. Peleciniidae with only one extant species has a diverse past as well, one additional genus is known from Oligocene and 17 genera and 48 species have been described from the Jurassic and the Cretaceous. In addition to these, one extinct family, Mesoserphidae, has been placed in Proctotrupoidea. According to Ren *et al.* (2019), it included 23 genera and 54 species from the Jurassic and the Cretaceous. *Anitchellia* Rasnitsyn & Jarzembowski, 1998 with two species from the Lulworth Formation, Durlston Bay, Dorset (140 Mya to 145 Ma) (Rasnitsyn *et al.*, 1998) and *Sinuijuhelorus baektoensis* Jon, Won, So & Jang, 2019 (Jon *et al.*, 2019) should be added to this total.

Tertiary fossils of the small proctotrupoid groups are rare. The discovery of a second Heloridae is thus of interest as such. The new fossil forces to open the question of identifying fossil proctotrupoid species and indeed, whether the families are monophyletic at all.

The terms used for the description are those from Huber & Sharkey (1993) and Masner (1993).

### **Systematic palaeontology**

**Order Hymenoptera Linnaeus, 1758**

**Superfamily Proctotrupoidea Latreille, 1802**

**Family Heloridae Förster, 1856**

**Genus *Helorus* Latreille, 1802**

***Helorus arturi* sp. nov.**

(Figs 1–3)

**Material.** Holotype, sample JMC-BA-HY-1, presently in MZH, male from Poland, Gdansk City area, close to river Wisła (Vistula), embedded in a lancet-shaped piece of Baltic Amber, size 3.1 cm / 0.8 cm / 0.5 cm, weight 0.7 gram. Sample JMC-BA-HY-1, JMC collection, presently deposited in MZH, Helsinki.

**Etymology.** Named after Artur Michalski, Poland.

**Diagnosis.** *Helorus arturi* sp. nov. differs from all extant *Helorus* species by the well-developed 1/Rs vein on fore wing. In general appearance, it is similar to *H. striolatus* (Cameron), with slender petiole, slender stigma and sparsely punctate mesoscutum, but besides the wing venation, it differs from it by the fairly equally spaced and orderly longitudinal grooves, longer petiole, more elongate, relatively longer and flatter stigma and elongated cell 2R1. The only other *Helorus* species known from Tertiary, the type-species of the genus, *H. funestus* Statz, (Statz, 1938) differs from *H. arturi* sp. nov., as well as all extant *Helorus* species by its short syntergite, plump body and robust legs. It too has a well-developed 1/Rs vein.



**FIGURE 1.** *Helorus arturi* sp. nov. Holotype, lateral view. Scale bar = 1 mm. Photo A. Michalski.

**Locality and horizon.** Eocene deposits, age 40–50 Ma (Weitschat & Wichard, 2008).

**Description.** Length: wasp 5.7 mm, fore wing 4.1 mm.

#### *Head*

Antennae dark brown; flagellomere two 1.6 times as long as scape, 4.5 times as long as wide; pedicel 2.5 times as long as flagellomere one (the annulus); two 1.2 times as long as three, four and five of equal length, both 1.2 times as long as six, which is about 1.1 times as long as seven, which is of equal length with 8–13, 14 slightly shorter than the previous one and 15 elongated, as long as four; vertex poorly visible due to distortions caused by flatness and curvature of the amber piece, genae shiny, with sparse minute punctation; mandibles endodontic, long and slender, close to apex curved mediad, on basal third thicker and wider, with stout tooth mediodorsally and lateroventrally.

#### *Thorax*

Mesosoma blackish, 1.45 times as long as high; scutum smooth, minutely punctate; mesopleuron with fairly dense but minute punctation, with isodiametric microscopic mesh; metapleuron coarsely reticulate and with stronger punctation; mesoscutum smooth, with minute sparse punctation, notauli deep with coarse punctures; scutellum smooth, without

posterior carina; metanotum coarsely crenulate anteriorly, smooth and without carina posteriorly; propodeum coarsely reticulate, cells formed by shiny carinae, with fairly strong punctation and distinct microsculpture.

#### *Legs*

From trochanters on, all legs paler in color than rest of body; claws pectinate; tibial spurs 1-2-2.

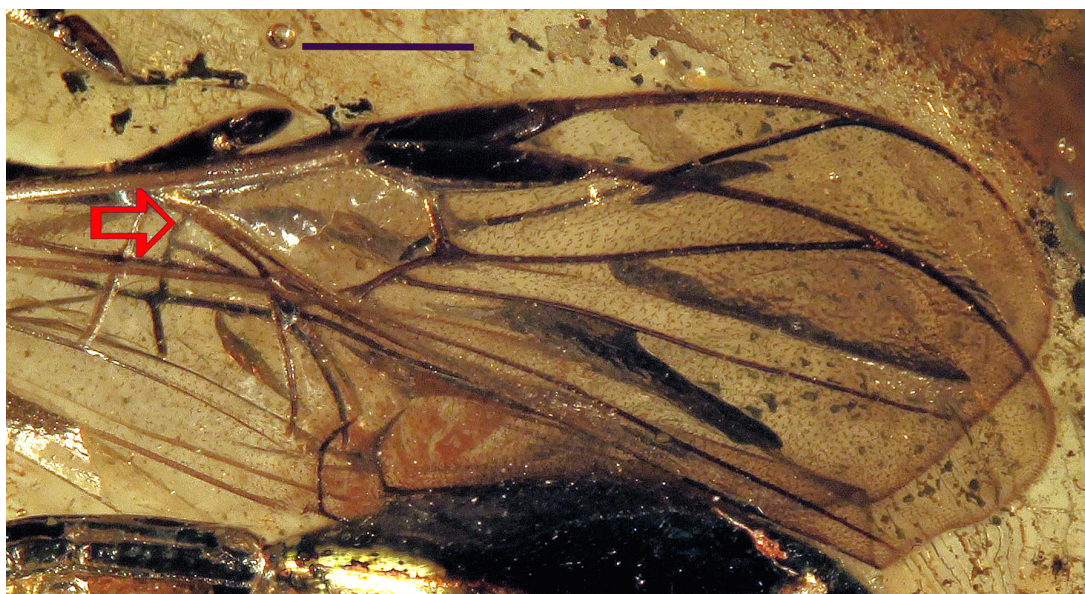
#### *Wings*

Fore wing with slender stigma (Figs 2, 3), 4.2 times as long as its maximum width; vein 1R 1.3 times as long as length of stigma, cell 2R1 elongated, more than 5 times as long as high; vein 1/Rs entire, tubular.

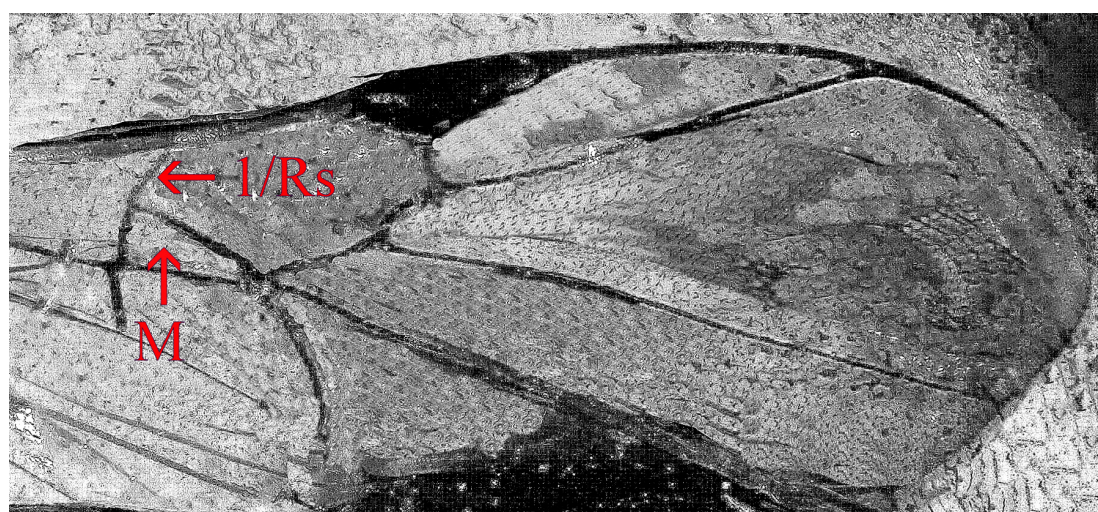
#### *Metasoma*

Petiole slender, in lateral view 3.8 times as long as its maximum width, coarsely and orderly costate and somewhat less strongly reticulate between costae, syntergite strongly narrowed basally (Fig. 1), sparsely and minutely punctate, microsculpture distinct, forming mesh of very narrow, elongate cells. Sternum with distinctly stronger and denser punctation than dorsum.





**FIGURE 2.** *Helorus arturi* **sp. nov.** Detailed image of wings, left wing warped close to radius, right wing flat open. Red arrow indicating the tubular 1/Rs vein in right wing. Scale bar = 0.5 mm. Photo A. Michalski.



**FIGURE 3.** *Helorus arturi* **sp. nov.** Right mesothoracic wing, photomanipulation. Triangular median cell (M) and vein 1/Rs shown with red arrow.

## Discussion

*Helorus arturi* **sp. nov.** is in most respects very similar to the extant *Helorus* species. It has toothed claws, long mandibles with three teeth, antenna with 15 flagellomeres including the annulus, front wing with triangular M cell, metasoma with slender petiole and syntergite longer than the remaining caudal tergites combined. *H. arturi* **sp. nov.** differs from the extant *Helorus* species in having a well-developed 1/Rs vein, a character it shares with the type species of the family Heloridae, the Oligocene fossil *Helorus funestus* Statz 1938. This is an interesting character as its lack is used to identify extant members of the family Heloridae (Masner, 1993; Mühlhäuser, 2015).

Fossil proctotrupoids were not included in Sharkey *et al.* (2012). Considering the large number of these taxa, it is worthwhile to look at the characters used to classify them. This will illuminate the placement of extant and extinct *Helorus* as well.

Pelecinidae is a recognizable, robust clade even after 165 Ma of evolution, as shown by Shih *et al.* (2010). This important study demonstrated that the peleciniid wing venation had changed substantially during their evolution and that the presence of the 1/Rs vein was a plesiomorphic feature in this family. The triangular M cell, so prominent in extant Vanhorniidae and Heloridae, is possibly present in one peleciniid, the Jurassic *Archaeopelecinus tebbi* Shih, Liu & Ren, 2009, and definitely present in all Cretaceous

Heloridae. Taking into account the results Sharkey *et al.* (2012) obtained with modern taxa, the triangular M cell may well be a synapomorphy for the entire clade Austroniidae (Vanhorniidae (Heloridae, Proctotrupidae)), secondarily and independently lost in Austroniidae and Proctotrupidae. The venation of the Austroniidae wing with no M cell could be a result of a fusion of veins M, Rs + M and Cu, whereas the venation in Proctotrupidae is strongly reduced. In any case, the 1/Rs vein is definitely present both in Vanhorniidae and Mesozoic Heloridae.

Extant Heloridae differ clearly from extinct ones. The extant ones can be identified with the combination of characters: triangular M cell (plesiomorphy), loss of vein 1/Rs (synapomorphy) and flagellum with anellus (plesiomorphy, as present in *Helorus arturi* n.sp. as well). Vanhorniidae, the sister-group to Heloridae + Proctotrupidae, is easily defined by the exodontic mandibles and compact metasoma with ventral groove for the external ovipositor, all apomorphies.

If the entire described history of Proctotrupeoidea is taken into account, Heloridae become unrecognizable, a group without any external synapomorphies. The triangular M cell is shared with Vanhorniidae, and either a synapomorphy for the clade Vanhorniidae + (Heloridae, Proctotrupidae) or a plesiomorphy. The absence of vein 1/Rs is a synapomorphy for the extant helorids only, all fossil helorids having the vein. The flagellar annulus found in all extant *Helorus* is present in *H. arturi* sp. nov. from the Oligocene, but only in one of the many Cretaceous fossil helorids, *Archaeohelorus hoi* Shih, Feng & Ren (Shih *et al.*, 2011). Two further species placed in *Archaeohelorus* are from the Jurassic and may or may not have an anellus (Shih *et al.*, 2014).

Most of the Jurassic and Cretaceous Heloridae are quite different from the extant ones, with less compact metasoma and a large number of flagellomeres, resembling the extinct Mesoserphidae. Other forms like *Sinohelorus* Shi, Zhao, Shih & Ren, 2013 and *Bellohelorus* Li, Shih & Re, 2017 have a metasoma more like those of the extant helorids with well-developed syntergite, but they have a large number of flagellomeres and a plesiomorphic flagellomere one. The diagnostic difference between wing venation of fossil Heloridae and Mesoserphidae is in the form of the M cell. Species with rectangular M cell are classified as mesoserphids, the ones with triangular ones being helorids. Roproniidae fossils include forms with variation in this feature.

The only previously known *Helorus* fossil from the Tertiary, *H. funestus* from Oligocene Rott deposits (Statz, 1938), differs substantially from *H. arturi* sp. nov. It is plump rather than slender, has stocky legs, short petiole and syntergite shorter than rest of metasoma. Unfortunately, the antennae were not completely visible in the only known specimen.

The overall structure of the extinct Heloridae seems to reflect the presence of two general types, one resembling

Mesoserphidae, the other more similar to modern Heloridae. This split may have existed all the way to Tertiary, *H. funestus* Statz, 1938 representing the last known representative of one of the lines, the other still extant.

When all known extant and extinct species are taken into account, there are significant problems in defining Heloridae, Mesoserphidae and Ropronidae. The recent erection of yet another fossil family, Peleserphidae (Zhang *et al.*, 2018) complicated this matter further.

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